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MOSQUITOES in CONNECTICUT

Robert C. Wallis

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Acknowledgements

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MOSQUITOES in CONNECTICUT

Robert C. Wallis

Mosquitoes have long been among the most troublesome insect pests in Connecticut. Mosquito control became clearly a matter of both private and public concern by 1900 when research proved that certain species transmitted malaria. At about the same time, pest species in shore areas became a real nuisance as people had more opportunities for vacations and outings. Today, when thousands of homes are in or near woodlands, kinds of mosquitoes formerly unimportant as pests invade yards and houses in the suburban forest. This report reviews early and recent research and control activities in Connecticut, gives information on many species found in the State, and presents principles of control developed after intensive study of many different situations over more than a half century.

MOSQUITOES, MALARIA, AND MARSHLANDS

Prior to the 20th century mosquitoes in Connecticut were an annoyance to be lived with and endured. By 1900, when it was established beyond all doubt that malaria was transmitted by *Anopheles* mosquitoes, Dr. W. E. Britton, the State Entomologist, initiated plans for mosquito control.

Malaria had been known to occur here for almost 250 years prior to 1900, but was not epidemic or widespread until after 1860 when it broke out in the southwestern corner and gradually spread over the State. Soldiers returning to their homes after the Civil War brought malaria from the South, and by 1882 practically every town was affected. The almost universal administration of quinine suppressed symptoms of malaria and epidemics became unknown. The death toll from malaria, however, was estimated at an average of 125 a year in Connecticut as late as 1894-1900 (1).

Dr. Britton, assisted by Mr. H. L. Viereck and Mr. B. H. Walden, made a survey of mosquitoes in the State, and in 1905 Dr. Britton and Mr. Viereck published "A Report on Mosquito Investigations in Connecticut" (1). This report disclosed 22 mosquito species in the State, and gave the distribution of the malarial mosquito in major population centers.

In this early work health officers were assisted in locating the breeding places of malarial mosquitoes. Filling or draining breeding areas was given first attention, and the use of oil was recommended in emergencies to kill wigglers.

Interest in control of malarial mosquitoes continued for several years, and the importance of pest mosquitoes became more widely recognized. Because of this interest, in 1912 a bulletin was written by Dr. Britton in which he noted that salt marshes were being ditched and drained and tide gates installed to prevent flooding by perigee tides (2).

In an act approved May 29, 1913, the General Assembly states: "Any accumulation of water in which mosquitoes are breeding is hereby declared to be a public nuisance," and health officers may "cause such breeding places to be . . . treated in such manner as to prevent the breeding of mosquitoes."

Two years later an act was passed authorizing the Director of The Connecticut Agricultural Experiment Station to eliminate mosquito breeding places or areas in cooperation with towns or groups of citizens.

Under the provisions of this act as revised from time to time, most of the salt marshes were ditched and drained, and the ditches and tide gates maintained by the State. This work functioned so effectively under the leadership of the State Entomologist that malaria became almost unknown in Connecticut.

The malaria vector, *Anopheles quadrimaculatus,* was concentrated in the low marshlands and fresh water collections along the shore, and the coastal salt marshes were the source of the pest species *Aedes sollicitans.* Therefore, control activities were originally concentrated in the coastal area where there was about 17,000 acres of tidewater marshland suitable for mosquito breeding. Hundreds of miles of ditches were dug to drain the stagnant pools and to circulate the tide water. Tide gates were installed at strategic places to prevent flooding of salt marsh areas where drainage did not lower the water level sufficiently. These drainage ditches had to be cleaned periodically, the banks recut, and blocking debris removed. This was accomplished by hand labor using hay knives, potato hooks, scoops, and shovels. Because of shortage of labor in 1949, Robert C. Botsford of the State Mosquito Commission designed a lightweight inexpensive ditch cleaning machine. This machine, called a power scavel, consisted of a one-piece steel double mouldboard plow with a tongue curving downward like the cross section of a ditch. This was mounted on the loading arms of a tractor which straddles the ditch and pushes the device forward, forcing mud up the tongue and away from the ditch. Because of the efficiency of this new method of cleaning and cutting ditches, Connecticut enjoyed low-cost effective mosquito control along the coastal salt marsh areas.

In 1939 this control work had been assigned to a State Mosquito Commission composed of representatives of the Experiment Station, Department of Health, Board of Fisheries and Game, and Water Commission. In 1951 it was transferred to the Section of Mosquito Control in the Bureau of Environmental Sanitation of the State Department of Health. This Section of Mosquito Control has concentrated its efforts on the salt marsh mosquitoes along the coastline. The responsibility for research on mosquitoes has remained with the Experiment Station.

Fig. 1. Egg raft of *Culiseta melanura*. The mosquito carefully packs the eggs together into a "boat" or raft which floats on the water surface.

LIFE HISTORY AND BIOLOGY

Mosquitoes belong to the same group of insects as the flies (order Diptera). They have two wings in the adult stage, and mouthparts in the form of a long slender proboscis fitted for sucking. They are readily distinguished from other flies in that the veins of their wings have scales, which are absent on most other flies.

Life Cycle

Mosquitoes grow through four distinct stages: Egg, larva (or wiggler), pupa (or tumbler), and adult. The larva and pupa develop in water and cannot exist elsewhere, and few types of natural accumulations of water are generally unsuitable for mosquito development (3). Among these few, however, are large lakes, ponds, and rivers. Except along shallow, weedy margins, such larger bodies of water seldom serve as mosquito breeding places because the action of winds and waves disturbs the quiet water surface necessary for the larvae. Where the banks are steep and clean there are no sheltered "nooks" in which the larvae can hide from predatory fish. In deep water the material which serves as food lies deeper than the fragile larvae can dive, and in swift streams the wigglers are swept along by the water current so fast they neither feed nor puncture the surface film to breathe.

Breeding Areas

Mosquito larvae develop in the less obvious places. The quiet water in pot-holes under the marsh grass, the leaf-filled puddle or seepage spot covered with bushes in the woods, and the murky rainwater collected in an abandoned automobile tire are not likely to be seen at first glance, but they are the places in which mosquito larvae are often found. A particular species, however, may occur more regularly in some types of water than in others. It was once believed that mosquitoes

scattered their eggs more or less indiscriminately. The absence of a given kind of larva from a certain type of habitat was thought to be because the water was unfavorable for larval development. It is now known, however, that the oviposition habits of the female control the distribution of larvae in nature. For instance, females of most species will not lay their eggs in salt waters even though the larvae are perfectly able to survive there. Thus, such species are never found in brackish tidal water along the seashore but are restricted to fresh-water habitats (4, 5).

Mosquitoes exhibit three general types of egg-laying habits: Eggs may be laid on the water surface so as to form rafts, or singly on the water surface, or at the edge of the water on moist surfaces. Mosquitoes that lay their eggs in rafts select a quiet water surface where the female rests on the water and carefully packs the eggs together to form a floating mass or raft (Fig. 1). Several species of *Anopheles* drop the eggs while hovering over the water in an "obstetric" or "oviposition dance." The eggs are not deposited until after the female has "tasted" the water (6). Those species which seek the moist soil or vegetation at the edge of a water surface deposit the eggs just above the waterline where the eggs remain until rainfall raises the water level to flood them.

Types of Eggs

Mosquitoes can also be divided into classes depending on whether or not their eggs enter into a period of dormancy. In Connecticut, those common species laying "non-dormant" eggs are included in the genera *Anopheles, Culex, Culiseta,* and *Mansonia,* while most of those in the genus *Aedes* lay eggs which become dormant. Dormant-type eggs usually survive drying, while non-dormant types do not (7).

Non-dormant type eggs usually develop and hatch within a few days after deposition. Between 70° and 80° F., the hatching time of the eggs is about 2 days. This incubation time may be shortened by higher

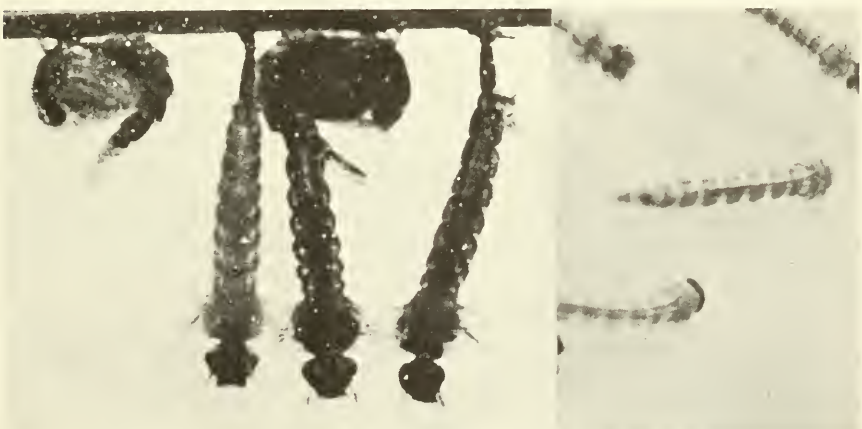

Fig. 2. Larvae and pupae of *Aedes vexans* beneath a water surface (left) and larvae of *Aedes aegypti* (right).

temperature or lengthened by lower temperature. The non-dormant eggs are easily killed by drying and are generally found in more permanent water sites, where one generation of the same mosquito succeeds another throughout the summer season.

On the other hand, those species of *Aedes* which produce the dormant-type eggs survive from one season to another, even during dry seasons, because the eggs are very resistant to drying (8). After oviposition the larva develops in the egg to a certain stage and then becomes dormant. During this time the egg may remain dry for long periods without harm. When the egg is subsequently flooded with water, the larva rapidly completes its development and hatches (Fig. 2).

Larval Feeding and Development

Once the eggs have hatched, the growth rate of the larvae is affected by many factors such as temperature, crowding, and availability of food. At laboratory temperatures most will complete larval development in about a week. Some species, however, have a very prolonged development even at high temperatures, so that it is difficult to assign a given length of time for development from egg to adult. Factors other than temperature also affect the rate of development of the larvae. Crowding is known to retard growth even when food is abundant, probably because of excessive larval activity.

Larvae of practically all mosquitoes are indiscriminate in their feeding habits. They eat a large variety of diatoms, desmids, other algae of various sorts, protozoans, and plant debris. *Psorophora ciliata* is the only true mosquito in Connecticut which is predaceous in the sense that it eats aquatic animals. The larvae of all species feed and develop in four stages of growth. As the larvae grow larger, they reach a point where the rigid body covering becomes too small, and it is shed in a moulting process. At the end of the fourth moult, or instar, the pupal stage develops.

Pupal State and Emergence of Adults

In the pupal stage (Fig. 2) most mosquitoes are tolerant of drying; emergence is usually successful even though the pupae may be stranded on moist earth at the edge of a pool. The adult mosquito develops in the pupal state, and at time of emergence the pupa usually floats on the surface of the water, its skin splits open, and the adult mosquito crawls out, using the pupal skin as a float or raft upon which it rests until the wings and body are dry. Male pupae are usually smaller and develop more quickly than female pupae. Therefore, the first mosquitoes flying in a given population are males.

Mating and Swarming

As a rule, mating takes place soon after the adult mosquito emerges. In the northern states mating of most mosquitoes takes place in a "swarm" formation. Under certain conditions males begin a peculiar dancing flight which is an essential part of the mating process. In a swarm only a few mosquitoes may take part or many thousands may participate. The swarm usually forms at times of low light intensities,

in the evening, early morning or during cloudy weather. Individuals are attracted to the swarm by the humming sound produced by the wing-beat frequency. The mating process is brief, and the female then drops out of the swarm and begins the search for food.

Feeding Activity of Adults

Both male and female adult mosquitoes feed during their active life on plant saps and nectars. A wide variety of plants are utilized but little is known of the preferences for any specific kind except that the sugar content is the essential attractant. Research has shown that sucrose is the most attractive plant sugar. The plant saps and fruit juices which form the natural diet of mosquitoes between blood meals are especially rich in this kind of sugar (9).

With very few exceptions, female mosquitoes must have a blood meal before they can develop eggs. In obtaining this blood meal the mosquito "bites," or probes the needle-like proboscis into the skin and usually injects a salivary secretion containing an anti-coagulant to keep the blood from clotting. The itching and swelling at the site of the mosquito bite is an allergic reaction to the foreign protein in the salivary secretion. Those people who are more allergic experience more discomfort from mosquito bites than others. In addition to experiencing more of a reaction, some people may be bitten more often than others. The factors favoring biting are not well understood, although warm temperatures, high humidities, and dark colors are known to be attractive to most mosquitoes. Carbon dioxide gas in small amounts seems to attract some species, and a reduction in light intensity appears important in stimulating most female mosquitoes to feed. Practically all species bite predominantly between dark and dawn. The increased moisture which prevails at this time probably is important, but the critical factor in triggering activity is the reduced light. Though this is the general rule, there are several species of *Aedes* which often bite during the mid-day —even in bright sunlight. Fortunately, these species are few.

Much has been written about the animals on which female mosquitoes may feed. Most species seem to be able to feed on a variety of animals, and few limit their attacks to a single kind of host. Much of their choice is made from the animals most convenient to the places where the mosquitoes breed. Thus, the "domesticated" house mosquito, *Culex pipiens,* breeds in water in cans or other residential clutter and enters houses freely to feed on man (10). *Culex restuans* breeds in the country and feeds chiefly on domestic and wild birds. Whatever the source of the blood meal, most female mosquitoes will develop eggs within 3 to 5 days after the meal, depending upon the temperature. These eggs are usually laid in the evening when other mosquito activity is also at its peak.

Life Span

The number of times a female mosquito will feed on blood and develop eggs depends to a large extent on its longevity. While little is known of this important phase of mosquito biology, it is generally ac-

cepted that most species can lay several egg clusters after mating only once, but must feed on blood before developing each batch of eggs. The life span of the mosquito is related directly to moisture in the air, and all mosquitoes are very susceptible to death from lack of moisture. For this reason mosquitoes are generally most active when humidity is high. This condition usually prevails in the evening so that it is predominantly at this time that mating, feeding, migration, and oviposition occur. Some species, however, are especially adapted to withstand hot dry air. The plains species, for example, are active and feed during the day in the hot sunlight when the other kinds remain in shaded protected resting places under foliage. Forest mosquitoes, on the other hand, are often found in the daytime, but not in exposed sunlit places. In wooded areas, of course, there is more moisture and less light than in open fields and pasture land.

Distribution of Adults

These environmental factors are important in the distribution of adult mosquitoes, since the woodland species do not usually fly across hot, dry, open, sunlit fields. They prefer to remain in the cool, moist woodland where conditions are favorable for their survival. While some species can often be scattered widely by wind currents, the majority of mosquitoes remain close to their breeding places. Since they are fragile and weak fliers, they usually take shelter under vegetation when wind velocities rise above 5 miles per hour, and few are spread unless more violent winds or storms occur. Some species are more subject to dispersion by wind than others. *Aedes sollicitans,* breeding in the salt marshes along the seashore, and *Aedes vexans* in open field and windswept pastures, are likely to be dispersed more regularly and farther than forest species breeding in protected woodland.

Overwintering

The question most often asked about mosquito biology is, "How do they overwinter between breeding seasons?" Here in Connecticut the most abundant mosquitoes belong to three major genera: *Anopheles, Culex,* and *Aedes.* These groups have different means of survival between seasons. Generally, the adult female *Anopheles* and *Culex* go into hibernation during the winter in protected habitats or resting places. On the other hand, the *Aedes* are killed off by the cold, dry air late in the fall, and the species survives only in the dormant egg stage. Three of the rare species are known to overwinter in the larval stage. The wigglers remain in a suspended growth or dormant stage in water under the ice, and some may even survive freezing (11).

The overwintering of mosquitoes is important in the problem of disease transmission and has been the subject of special research. It is known that a mosquito which transmits malaria or virus disease remains capable of spreading it for the rest of its life after being infected by feeding on a diseased host. If the mosquito survives the winter as the *Anopheles* do, it can then spread disease during the following year and provide a reservoir in nature from which new epidemics may start. However, results of recent research clearly indicate that the number

of mosquito species which hibernate in Connecticut is quite limited (12). Of the six species found in winter resting places, only *Culex restuans* is known to be capable of transmitting eastern encephalitis, and no virus has been found in them in Connecticut. Other studies here show that unlike the *Anopheles,* female *Culex restuans* which have taken bird blood (and thus had an opportunity to become infected) are sensitive to cold and cannot hibernate (13). Those which hibernate in caves, cellars, and deep rock crevices come from late summer generations which have fed only on plant saps and nectars. Thus, as a result of these studies, it is now known that overwintering mosquitoes apparently do not provide the link connecting epidemics of eastern encephalitis from year to year.

Differences in overwintering directly influence the seasonal distribution of species of mosquitoes.

Seasonal Distribution

Generally the first sign of mosquito activity in the spring is the appearance of *Aedes* larvae in melted snowpools. These are the early spring species, and the time of their occurrence depends upon the beginning of the spring thaw of ice and snow.

The many people who dwell in the suburban forest, and those who venture out in the spring season for a hike, horseback ride, picnic, or to uncover the bulbs in the yard, often become aware of the mosquito population by a ferocious biting attack. No amount of emptying rain barrels, poking at clogged gutters, or spraying around the yard will protect the citizen from this attack, because the mosquitoes biting in March, April, May, and June come predominately from nearby woodland pools where species of the springtime *Aedes* develop. In the pools formed by melting snow and early spring rains the dormant eggs on the ground become active and hatch when water covers them. The immature developmental stages or larvae are active and grow in cold water. The adult mosquitoes emerge from the pupal stage before the woodland pools dry up, often before the leaves are on the trees.

Fortunately, the several species in Connecticut that appear early in the spring produce only one generation each year. After a biting attack in which the female mosquito obtains a blood meal, eggs are developed and laid on the moist ground around the edges of the woodland puddles and pools. The eggs develop for a few days on their moist substrate and then become dormant until the next spring when the stage is set for another brood to hatch. After depositing the eggs the female mosquito may feed on blood again if the weather remains cool and humid, but usually she is short lived and dies as warmer, drier air appears late in the springtime. Consequently, most of the mosquitoes that are so troublesome early in the season usually die before June and are replaced by mid-summer *Aedes,* which develop late in the spring and increase throughout the summer. Thus the mosquito population is simply a succession of different species developing in sequence from springtime into the fall season.

Species which overwinter as adults (most *Anopheles, Culex, Culiseta, Uranotaenia*) are usually the first seen in the springtime. These are,

of course, the females which have come out of hibernation seeking a blood meal. They are rather few and generally difficult to find for several months while eggs are being laid, and hatched, and until the first larval generation has developed. The largest population of these species develops in late summer and fall; therefore, annoyance by mosquitoes early in the summer is likely to be from quite different species than those which are bothersome later in the season.

LOCAL MOSQUITOES AND DISEASE TRANSMISSION

In 1794 an outbreak of yellow fever in Connecticut caused 64 deaths out of a total of 160 cases in New Haven. There were also cases in Middletown. A ship from the West Indies probably had brought some infected mosquitoes to Connecticut. Ordinarily, yellow fever does not now occur in the State because the mosquito carrier of the virus, *Aedes aegypti*, has not established itself as a native species; and because modern methods of quarantine and decontamination of ships and airplanes arriving from tropical areas lessen the chance of accidental entry of the carrier.

Malaria likewise has become mostly of historic interest, but for another reason. The mosquito carrier of the disease, *Anopheles quadrimaculatus*, is still present, but is kept in check in the marshy coastal areas by mosquito control. The few which develop are unlikely to become infected because all reported cases of active malaria are under medical treatment.

Another mosquito-borne disease, eastern equine encephalitis (eastern "sleeping sickness"), has now become a potential public health problem. Encephalitis means inflamation of the brain. There are many reasons for such inflamation, including an infectious type caused by a virus. The specific virus of concern here is called the eastern encephalitis virus because it is found in the United States only along the eastern seacoast and is different from the western encephalitis viruses found in other parts of the country.

Research on this disease and its possible vectors of transmission has been conducted intensively since 1953. Because other types of this virus were transmitted by mosquitoes, special attention has been given to study of possible vectors. Six species of mosquitoes occuring in Connecticut have been shown capable of transmitting the virus in laboratory experiments. One of these, *Culiseta melanura*, is known to spread the disease in other states, and is probably very important in transmitting the virus among wild birds. This mosquito does not usually feed on man and is not commonly found in Connecticut; so that here it cannot be considered very important as a vector. Another species, *Aedes vexans*, was found naturally infected with virus during field studies of the 1959 epidemic (14). This mosquito has been on the "suspected" list since 1935, when it transmitted the virus in laboratory tests. In the 1938 epidemic in Massachusetts, it occurred in all areas where the disease appeared.

Aedes vexans is a fierce biting mosquito and feeds not only on man,

but also on horses, cattle, and birds. It enters houses and barns readily, especially during August and September. Since it is a confirmed carrier of virus, control of this species is important when an epidemic occurs.

It is believed that the eastern encephalitis virus does not pass the winter in Connecticut, but is carried in each season by birds migrating from tropical areas. Presumably the disease is transmitted to other birds and to horses by mosquitoes. Pheasants are highly susceptible to the disease, and infection in domestic flocks is usually the first seasonal warning. Rearing of pheasants on game farms, therefore, furnishes a very sensitive indicator by which public health officers may be alerted to the virus activity.

The fact that there have been no cases of eastern encephalitis among humans in Connecticut has been the subject of much speculation. It is possible that epidemic conditions have not existed; in other words, the virus, the mosquitoes, and the human hosts were not all present at the same time and place. It is also possible that the ditching and draining of salt marshes has reduced the numbers of *Aedes vexans* that breed along the inland fringes of the coastal marshes to the point where populations of this mosquito do not build up to dangerous concentrations.

Because infants and young children are especially susceptible to the disease, they should be protected from mosquitoes, especially in the period between August and the first hard frost. *Aedes vexans* bites during the day as well as in the early evening. The daytime biting occurs most often in shaded places in the late afternoon, and particularly during these hours children should be protected from mosquitoes.

IMPORTANT SPECIES IN CONNECTICUT

Mosquitoes are generally classified by the species, genus, tribe, subfamily, and family to which they belong. Monographs may be consulted for such systematic classification (3, 7, 8, 11). Mosquitoes are also discussed according to the salinity of the water in which they develop. Some species prefer saline water, others are found only in fresh water. However, this general plan does not allow for the considerable overlapping that occurs among fresh water and brackish water mosquitoes in some of the most heavily populated areas near the sea. Mosquitoes that breed in coastal salt marsh areas migrate or are blown inland, and the fresh-water species are pestiferous in coastal areas for other reasons. Therefore, a more natural grouping of the species according to seasonal occurrence will be followed here. Accordingly, of the 38 species found in Connecticut, only three are numerous between March and June. These three may be easily distinguished from each other without the aid of highly specialized equipment and identification keys.

Aedes abserratus, Aedes stimulans, and Aedes cantator

The two most pestiferous species in the springtime are *Aedes abserratus* (Fig. 3) and *Aedes stimulans* (Fig 4). *Aedes abserratus* may be easily identified by the absence of white bands on the legs. The

Fig. 3. *Aedes abserratus.*

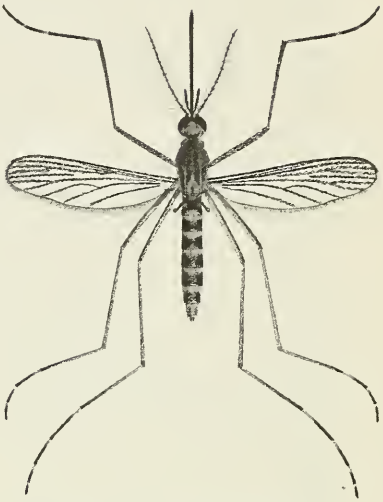

Fig. 4. *Aedes stimulans.*

pointed abdomen is also characteristic of the female mosquitoes in the genus *Aedes. Aedes stimulans* is recognized by the broad stripe on the back (or dorsal part of the thorax) and the many white scales intermixed over the surface of the body.

In the salt marsh areas the presence of another early *Aedes* is often painfully evident. *Aedes cantator* is a large brown mosquito with rather indistinct, transverse white bands on the legs and abdomen (Fig. 5). It appears early in the season, and larvae have been found in salt marshes as early as March 2. Large swarms of adults usually do not emerge until May and June. They become vicious biters which attack man, not only in the open during the daytime, but also in houses and after dark.

Unlike the fresh-water springtime species, *Aedes cantator* migrates and is carried by winds inland from the breeding places for considerable distances, invading shore towns and summer resorts. It differs also in that it produces at least two broods a year, one in May and another in June; and while brackish water is preferred, fresh-water pools are also utilized as breeding places.

These three *Aedes* species are the principal source of annoyance to people before and during June. Certain features in their biology and life cycle explain the great amount of trouble they cause. They do not confine their biting activity to evening and dusk but also bite throughout the day. They are particularly active in shaded areas, woodland, and forest margins, and consequently the suburban forest resident is right in the "line of fire" in his own backyard.

Not only does man suffer from daytime attack of these pests, but nesting birds and their fledglings are particularly susceptible. During the day when the parent birds are away foraging for food for the fledglings, the young birds in the nest are exposed to these day-biting mosquitoes. The young birds without their protective feather covering are defenseless against mosquito attack. Many deaths among young birds during the spring nesting season apparently are due to the blood feeding of the mosquito.

An important factor in the biology of spring pest mosquitoes is their length of life. While they usually produce but one generation a year (with the exception of *Aedes cantator,* which produces two) the adults live a long time and may bite more than once. The length of the adult lifetime depends largely upon the weather. If, as in 1959, the early summer is warm and humid, the adult mosquitoes do not dry out and die as is usual with the onset of summer and the appearance of hot, dry weather. Since they are active during the heat of the day and are therefore subject to extremes of heat and dry air, the usual onset of summer weather late in June in Connecticut virtually eliminates the adults from the springtime brood.

The weather in the spring is important in relation to the numbers of springtime *Aedes.* They hatch from dormant eggs deposited in pools during the preceding years. When the water in the pools disappears, the eggs remain dormant until they are flooded by water from melting snow and spring rainfall. If the eggs are not submerged by water warm enough to hatch them, they may hold over from year to year until adequate conditions occur. Thus, in the extremely cool spring season of

Fig. 5. *Aedes cantator*

Fig. 6. *Culiseta melanura*

1957 there was not suitable stimulus for a big hatch of dormant eggs. During the following spring season, in 1958, rainfall was insufficient to flood most of the woodland pools where there were dormant eggs (which are known to hold over for as long as ten years until favorable conditions occur for hatching). Then in 1959 there was melting of an ample snow cover, more than normal early spring rainfall, and higher than average early temperatures. Dormant eggs from previous years were provided with ideal hatching conditions. The result was a bumper crop of mosquitoes early in the season.

Culiseta melanura

While the *Aedes abserratus, A. stimulans,* and *A. cantator* are at their peak of activity, other species come into the picture. Fortunately, not all of them feed on man. Wild birds provide the blood meal for several kinds which appear late in the springtime and early in the summer. Two of these are quite different from the *Aedes.* They are *Culiseta melanura* (Fig. 6) and *Culiseta morsitans,* which develop from overwintering larvae. Since these are much less abundant than important pest species, and feed predominantly on birds and domestic fowl rather than man, they are not often encountered by people in Connecticut. However, one of them, *Culiseta melanura,* has been found a potential vector of transmission of equine encephalitis. In 1951, the virus of this disease was isolated from *C. melanura* collected in Louisiana by U. S. Public Health Service investigators. Later studies on vectors of transmission of eastern encephalitis have implicated this bog mosquito as the primary means for maintaining the basic infection chain in nature (bird-to-bird). Seventeen natural isolations of the virus have been obtained from this species in Louisiana, and a number of isolations have been obtained from it in Massachusetts and New Jersey.

Culiseta melanura feeds extensively on birds and is found primarily in sphagnum bogs and cedar swamps. It appears to be extremely selective in its breeding places and tends to choose secluded shady sites with cool, acid water in permanent fresh-water swamps. It is often found in the springtime associated with *Culiseta morsitans* which has very similar habits. Both species are subjects of special research to determine their significance in the spread of virus diseases.

Aedes canadensis

While *Culiseta melanura* and *Culiseta morsitans* are not particularly bothersome, at about the time they appear in the mosquito population two other species occur which devote much of their biting to man. These are two more *Aedes* that develop late in the springtime and early summer — *Aedes cinereus* and *Aedes canadensis,* shown in Fig. 7 and 8. These two compose the bulk of the biting population during the early summer in most inland areas of Connecticut. They are easily distinguished from each other in that *Aedes cinereus* has no bands of white scales on the legs and is a small brown mosquito lacking brilliant markings. *Aedes canadensis* on the other hand, has broad white bands on the legs. These white bands extend to both sides of the leg joints.

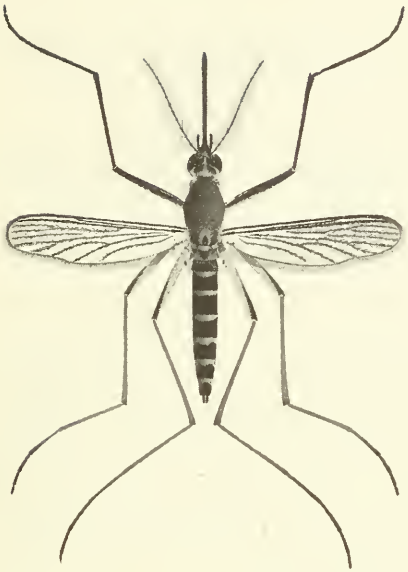

Fig. 7. *Aedes cinereus*

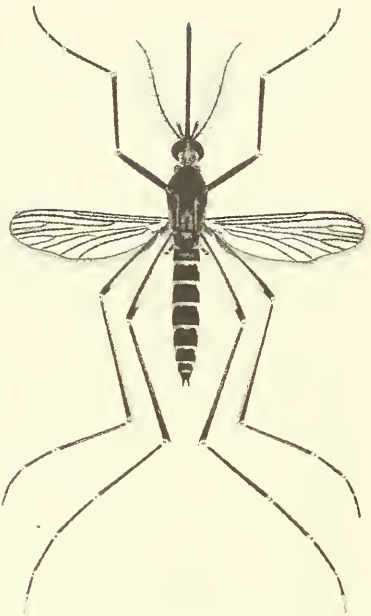

Fig. 8. *Aedes canadensis*

Aedes cinereus is apparently single-brooded, overwintering in the egg stage and usualy hatching in late springtime. The larvae are found not only in woodland pools but also in unshaded temporary rain filled pools and open marshes. They have been collected along margins of woodland streams and in a wide variety of aquatic sites which contain grass and emergent vegetation. This wide variety of larval habitats explains why *A. cinereus* becomes so abundant. The adults are troublesome biters on man and birds, and are most pestiferous in woodlands during mid-summer. They bite throughout the day in shaded areas and for this reason make their presence known to picnickers seeking to avoid the heat.

Aedes canadensis likewise introduces itself to anyone venturing into the woods or near them, from late springtime to the early fall season. This mosquito bites throughout the daytime, particularly in shaded areas. In addition to delivering a persistent attack on man, *Aedes canadensis* is a lethal enemy of fledgling birds late in the springtime. Nestling redwing blackbirds, in their nest in marsh lands near the woodland border, have been observed under continuous attack by this species while the parent birds were away. Since the nestlings were small, the persistent feeding by *Aedes canadensis* virtually drained them of blood. After witnessing such an attack, it is easy to understand why so many young birds die in the nest during seasons when mosquitoes are abundant.

Aedes canadensis larvae develop in temporary or semi-permanent shaded woodland pools containing fallen leaves and, to a lesser extent, in pools in stream beds, and in pools and ditches adjacent to wooded

areas. While the majority of the larvae hatch in the springtime from overwintering eggs, some are found late in the summer, and it is not known whether there is more than one brood during a season. The adults are apparently well adapted to hot weather because the adult population increases during the mid-summer season and persists until early fall.

Mansonia perturbans

Mansonia perturbans is a serious pest mosquito which appears in the early summer. It is easily recognized by the distinctive arrangement of black and white scales over the surface of the body (Fig. 9). There are seven broad bands of white scales on the hind legs, and the wing scales are black and white intermixed.

Special details of the life history account for the distribution and seasonal incidence of this mosquito. The larvae have a pointed air-tube which hooks into the roots of aquatic plants where oxygen is obtained. Therefore, the larvae remain deep below the surface of the breeding place. Generally speaking, the larvae are embedded in flocculent debris at the bottom of ponds or in the lower sides of floating islands or quaking bogs. Marshes with peat or muck bottoms favor larval survival. Only one or two areas in a town may be suitable for production of this species. Since the larvae remain attached to plant roots, however, many thousands may develop in just a few square feet of swamp or bog. When the adults emerge they may migrate as far as 15 miles.

The adults usually rest under leaves and low vegetation in cool, shady locations during the daytime, but may bite throughout the day. They have a strong tendency to enter houses and become a most annoying pest in the bedroom.

Fig. 9. *Mansonia perturbans*

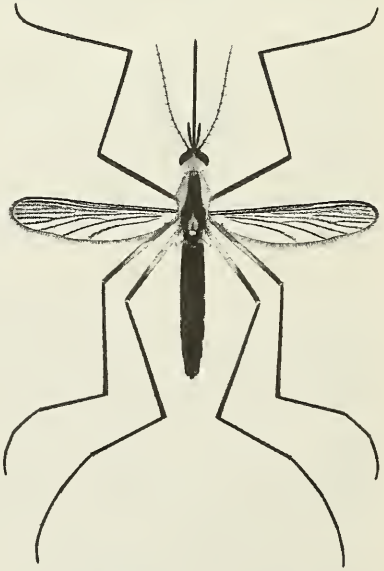

Fig. 10. *Aedes triseriatus*

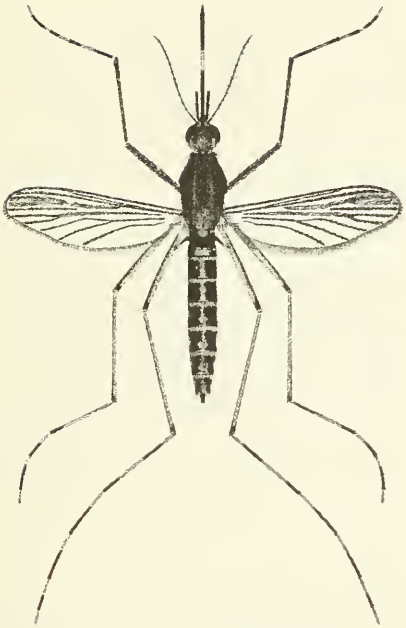

Fig. 11. *Aedes sollicitans*

Fig. 12. *Aedes vexans*

Aedes sollicitans

During the middle and late summer the two most important mosquitoes in Connecticut appear in force and make their presence known by a vicious biting attack. In the coastal salt marsh areas *Aedes sollicitans*, the "white banded salt-marsh mosquito," dominates the scene. From the inland edge of the salt marshes and northward over the rest of the State, *Aedes vexans*, "the flood-water mosquito," is widely distributed. These two species so dominate the late summer mosquito population that *most* people bitten between late July and October have been attacked by one of these mosquitoes.

These brown mosquitoes are easily recognized by the pattern of white scales on the legs and abdomen. *Aedes sollicitans* has a broad white band around the proboscis, or "stinger." It also has broad white bands on the legs and a white stripe down the length of the abdomen (Fig. 11). *Aedes vexans*, on the other hand, has very narrow white bands on the legs, so narrow that at first glance the bands may not be apparent. The narrow half-round patches of white scales on the abdomen are arranged in a pattern distinctive to this species (Fig 12).

Aedes sollicitans is one of the few mosquitoes which develops in saline water: this accounts for its strictly coastal and tidal plain distribution. The larvae are everywhere along the coast where salt-marsh grass grows, and are especially abundant in "soft" marshes just above the level of ordinary high tides. These conditions extend inland along the banks and swamps of tidal rivers which are brackish from the high tides.

When the adults have emerged from the salt marshes, they are not content to sit on the grass. Migrations for considerable distances are common. Boats and ships many miles off shore have been invaded by swarms of *Aedes sollicitans*, and the towns in coastal resort areas are often invaded by these mosquitoes from more than 10 miles away.

Any available bird or warm-blooded animal is subject to attack. Biting activity is most intense during the evening and is influenced by the wind velocity and temperature. Wind speed of over 5 miles per hour discourages the mosquito from biting, and most biting occurs when the temperature is above 50° F.

Unlike many of the other *Aedes*, the salt-marsh mosquito develops many broods a season, and for this reason may build up to tremendous numbers within a short time. Approximately 1000 miles of ditches drain salt marshes in Connecticut to control this mosquito. Before such control, it has been said that one couldn't tell the color of a cow in the pasture near the shore until after the mosquitoes had been brushed away. Workers in the fields and on roads had to swing switches constantly to fan the mosquitoes away, and coastal property had little real estate value as recreational or resort sites.

Aedes vexans

Intermingling with the *Aedes sollicitans* at the edge of the salt marshes is *Aedes vexans,* a bloodthirsty mosquito that attacks man and bird alike. Cattle and other large animals are also particularly vulnerable. Biting occurs during the day in shady places and becomes especially annoying at dusk and after dark. The adults enter houses and can make the bedroom a den of insomnia. They are able to migrate long distances from their breeding places, and flights of from 5 to 8 miles are not uncommon. The larvae are found in a wide variety of places including marshes, swamps, and shallow water in ponds, lakes, streams, rivers, puddles, dumps, rain barrels, and cow pastures. Woodland pools, the wooded flood plains of rivers, or any low ground subject to overflow or rain flooding provide breeding places. The only common characteristic of the breeding places of this species is the presence of fresh water.

Particularly heavy production of larvae is known to occur in the fresh water collected on the inland edge of the coastal salt marshes, but larvae are never found in the brackish water.

Aedes triseriatus

One more kind of *Aedes* is added to the list of very common mosquitoes which appear in the woodland late in the summer. *Aedes triseriatus,* "the tree-hole mosquito," is widely distributed in the woodland and is a persistent biter. It is black and is easily recognized by the silvery pattern of scales on its back (Fig. 10). It breeds in tree-holes which collect rain water. Connecticut would appear to offer unlimited breeding places for these when it is recalled that almost two-thirds of the State is woodland.

The adult mosquito lays eggs on the bark above the water in the tree-hole, and when the water level comes up after a rain, the eggs are

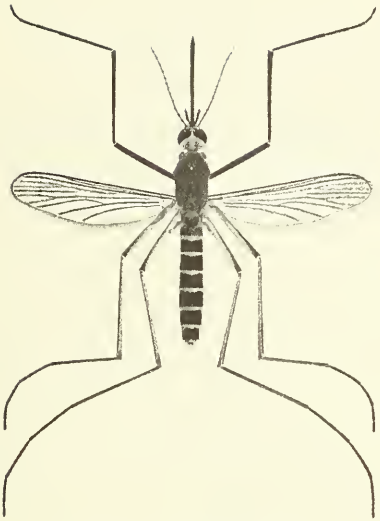

Fig. 13. *Culex pipiens*

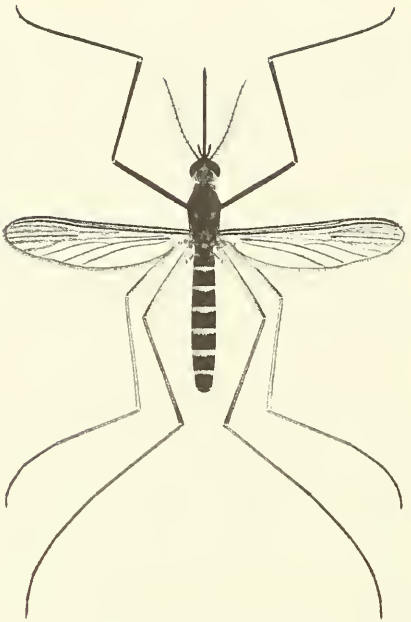

Fig. 14. *Culex restuans*

flooded and hatch. Depending upon the frequency of summertime rainfall, many generations a year can develop and even one tree-hole can produce enough *Aedes triseriatus* to make a neighborhood a miserable place to live.

Culex pipiens

During the middle of the summer and the fall season two other mosquitoes develop in great numbers almost everywhere in the State. These are *Culex pipiens* (Fig. 13), the common "house" or "rain-barrel" mosquito, and its close relative *Culex restuans* (Fig. 14). These may be distinguished from the *Aedes* by the blunt rounded abdomen, which is quite different from the sharply pointed abdomen of the *Aedes*. They differ from the *Anopheles* in that *Culex* wings are not spotted.

Culex pipiens may be readily distinguished from *Culex restuans* by the pattern of the patches of white scales on its back. The white bands across the abdomen of *C. pipiens* are narrow and curved whereas on *C. restuans* they are broad and generally straight without rounding at the sides. In addition, *C. restuans* usually has four white spots on the thorax which are entirely lacking on *C. pipiens*.

These two mosquitoes may perhaps be more easily distinguished by their habits. *Culex pipiens* is an urban "domestic" pest whereas *Culex restuans* is a wild species usually encountered out in the woods.

The *Culex pipiens* larvae may be found almost anywhere in stagnant water. There is no place so small and no water so foul as to bar this

species. Anything from a tin can half full of rain water to a sewer basin, cesspool, or manure pit may harbor larvae. Any pool of rain water that lasts from 8 to 10 days in a bucket, a tub, a rain barrel, or watering trough will serve as a breeding place. In cities and towns the sewer basins form an important source of supply of this mosquito. Where there are no sewers, cesspools serve as well; and where rain barrels or cisterns are in use, these are favorite breeding places. Neglected gutters, sunken lots in which rain water collects, ditches along the roads, and water in flooded basements are often found full of larvae. This mosquito will breed indoors as well as out if given a chance to lay its eggs on water in unused toilet bowls or flower vases. The ability to develop almost anywhere makes *Culex pipiens* the most common and widely distributed species.

The term "house mosquito" is expressive of the most objectionable habit of this mosquito — its persistent effort to get indoors. Other kinds of mosquitoes will get into houses through open doors or windows, or on the clothing of persons coming in; but *Culex pipiens* actually works its way through crevices, behind windows, and even through screens. It comes indoors not necessarily in search of food. Once it is in, of course, it invariably bites people. The bite is not so painful as some from other kinds of mosquitoes but is apt to be more lasting. *C. pipiens* has a special singing habit before it bites which is most aggravating. It will hover for some time, buzzing about, before deciding upon a satisfactory place to strike. This singing is often more annoying than the bite itself.

Culex restuans

Culex restuans is an outdoor mosquito, the most common one found around farms and suburban areas in the fall. Like *C. pipiens* the larvae can develop in almost any accumulation of rain water, large or small, and the species often is found in great numbers. Fortunately, it does not bite man to the extent that *C. pipiens* does, but prefers to take blood from domestic and wild birds.

Other habits of these species are similar, however, and both may be discussed at the same time. The adult female hibernates in almost any place which is dark and sheltered from the winds — barns, cellars, and outbuildings are especially favored. It has been said that almost every basement in any mosquito-ridden district harbors its quota of hibernating females. It is remarkable how so many can find their way into places to which there is no apparent entrance and where the windows and screens are closed.

Hibernation begins long before the breeding season ends, and some go into retreat early in September to be joined by others from late fall broods. Recent research has shown that the hibernating female does not require a blood feeding before overwintering. Nutrient material stored in fat during the larval stages and sugar from plant saps sustain the mosquito until spring.

As a rule these two species of *Culex* are not migratory and seldom fly farther than is necessary to obtain food and a suitable place to lay eggs. For this reason people often find that the mosquitoes biting them are

Fig. 15. *Anopheles quadrimaculatus*

Fig. 16. *Anopheles punctipennis*

from their own backyard. It is not uncommon to solve the mosquito problem in a neighborhood by treating an abandoned cistern, lily pond, or pool in a rock garden with a half cupful of oil. This is a much cheaper and more rational control than covering the entire area with DDT from an airplane.

Anopheles quadrimaculatus

Among the late summer mosquitoes the *Anopheles* come to our attention chiefly because they enter houses. The large black mosquitoes with long legs are about twice the size of most other kinds and make a distinctive appearance when they rest on light-colored walls. They are most often seen in bedrooms of summer cottages, in boat houses, and in basements of buildings in suburban and rural areas. During the summer the *Anopheles* come into shelter to avoid the heat of the day and in the fall they come in to hibernate.

The "malarial mosquito" is *Anopheles quadrimaculatus.* Since the Section of Mosquito Control has concentrated on the neo-coastal marsh lands where the breeding areas of this species principally occur, the malarial mosquito is much less common than might be expected. In fact, of four kinds of *Anopheles* common in the State, only two are found in large numbers, and these only late in the summer and during the fall. Both of these may easily be distinguished by their distinctive wing pattern. The one most often seen, *Anopheles punctipennis,* has white areas on each wing (Fig. 16); and the malaria vector, *Anopheles quadrimaculatus,* has four dark areas on each wing, as shown in Fig. 15.

Anopheles punctipennis

While both of these species are present in Connecticut, *Anopheles punctipennis* is by far the one most often seen. This is probably because the larvae develop in a wide variety of semi-permanent and temporary breeding places which are more likely to occur around residential areas. They are found in ponds, temporary woodland pools, springs, puddles in intermittent streams, roadside puddles, wheel ruts in muddy roads, eddies along margins of flowing streams, and in rain barrels and other artificial containers, — although preferring the cool, clear water of woodland hillside streams. This species of *Anopheles* may transmit types of malaria that infect birds, but these malarial parasites of birds are not able to cause disease in people. Since human malaria is no longer a problem in the State, the *Anopheles* mosquitoes are of little economic importance either as pestiferous species or as transmitters of disease, as long as the ditches in the neo-coastal marshland area are maintained.

OTHER SPECIES IN CONNECTICUT

The mosquitoes discussed so far are generally distributed throughout the State or are encountered in large numbers. They include those considered most important as pests and those which may transmit disease. In addition to these 14 species, many others occur. These are listed in Table 1, along with some biological information concerning the season of adult activity, special breeding places, host feeding range, and how they overwinter. Some of them are quite rare, while others may occur in considerable numbers in some localities and become pestiferous in a limited area.

PRINCIPLES OF MOSQUITO CONTROL

Effective control of mosquitoes begins with removal or treatment of breeding places, thereby lessening but not eliminating the need for other measures to give protection from biting. The removal or treatment procedures cut down the number of mosquitoes, the bite-prevention measures lessen the nuisance from those that escape treatment.

Removal and Treatment of Breeding Places

Ditching and draining

In many situations, stagnant water can be managed so as to prevent breeding. In the salt marshes, ditching and draining puts water from the grassy marsh into ditches where fish can eat the larvae. Ditching and draining is particularly applicable where the probability of breeding is sufficiently high each year to justify the expense. Similarly, malarial mosquitoes breeding along the shallow margins of fresh-water ponds or swamps can be controlled by straightening the banks and deepening the margins so that grass, which protects the larvae from fish, cannot grow. Sometimes flooding will accomplish the same purpose. For example, when the Lake Whitney dam in Hamden was raised 2 feet the mosquito breeding areas were flooded. These methods are particularly applicable in relatively large areas where mosquitos regularly breed.

Table 1. Other mosquitoes found in Connecticut, not major pest species.

Species	*Season*	*Adult habitat*	*Special larval breeding places*	*Biting preference*	*Overwintering stage*
Culiseta morsitans	Spring and summer	Woodland	Marshes and bogs	Birds	Larvae
Culiseta inornata	Spring, summer, fall	Open fields	Ground pools, ditches, artificial containers	Man and animals	Adult females
Anopheles crucians	Summer and fall	Swamps	Acid-water swamps	Man, animals, birds	Adult females
Anopheles walkeri	Spring, summer, fall	Woodland	Shaded swamps and bogs	Man, animals, birds	Eggs and adult females
Anopheles earlei	Spring, summer, fall	Swamps and bogs	Pools in swamps and bogs	Man, animals, birds	Adult females
Culex salinarius	Summer and fall	General area of breeding places	Fresh water, brackish and stagnant swamps	Man, animals, birds	Adult females
Culex territans	Spring, summer, fall	Woods and grassy fields	Vegetated pools and ponds	Frogs, small animals, birds	Adult females
Aedes taeniorhynchus	Summer	Salt marsh border thickets	Salt marshes	Man	Eggs
Aedes intrudens	Spring and summer	Woodland	Woodland pools and marshes	Man and animals	Eggs
Aedes trivittatus	Spring and summer	Woodland	Woodland pools	Man and animals	Eggs
Aedes aurifer	Spring	Bogs and woodland	Cranberry bogs	Man and animals	Eggs
Aedes sticticus	Summer	Woodland	Wooded flood plains	Man and animals	Eggs
Aedes dorsalis	Spring and summer	Meadows	Snow and rain pools	Man, animals, birds	Eggs
Aedes excrucians	Spring and summer	Woodland and meadows	Shaded grassy pools	Man	Eggs
Aedes fitchii	Spring	Woodland	Woodland pools and swamp	Man	Eggs
Aedes trichurus	Early Spring	Swamp border thickets	Snow pools in swamps	Man and birds	Eggs
Aedes atropalpus	Spring and Summer	General area of streams	Rocky pools	Man and animals	Eggs
Aedes grossbecki	Spring	Woodland	Woodland pools and marshes	Man	Eggs
Psorophora ciliata	Summer and fall	Open swamps	Small ground depressions	Man and animals	Eggs
Psorophora ferox	Summer and fall	Thickets and woods	Rain pools, stream margins	Man and animals	Eggs
Orthopodomyia signifera	Spring, summer, fall	Woodland	Tree cavities and artificial containers	Birds	Larvae
Uranotaenia sapphirina	Summer and fall	Woodland	Permanent ponds and lakes	Unknown	Adult females
Wyeomyia smithii	Spring, summer, fall	Swamps and bogs	Water collected in pitcher plants	Unknown	Larvae

Many pest species breed in shallow woodland pools that are not recognized as stagnant water. Sometimes these can be drained or filled, but at a relatively high cost.

In such situations, insecticides have been used to kill the larvae. Spraying in May for control of the gypsy moth in woodlands has left enough residue to kill larvae breeding in such pools throughout the summer. Treatment of these relatively small pools is of little significance to wildlife, because they are seldom inhabited by anything but mosquitoes and midges. Many of these pools are dry except in the early spring.

Other species breed in water hidden from view in tin cans, boats, barrels, catch basins, and other places that are not usually recognized as accumulators of water. Such breeding places may account for as many as half of the pest mosquitoes in a neighborhood, and there is no easy method of control. However, a few precautions for the prevention of mosquito breeding around the home should be taken before the use of insecticides is considered.

Breeding places around the home

In woodland settings, before leaves appear in the spring, the area around the house should be carefully examined for temporary pools and swampy places which can be drained or filled. Rain barrels and cisterns should be covered with screens. Sewage-disposal structures should be tightly covered and maintained so that there is no overflow. Ornamental pools may be stocked with fish. Clogged roof gutters and flat roofs should be drained. Provide drains so that water cannot accumulate under porches and in cellars, providing excellent breeding places for *Culex pipiens*. Mosquito eggs may be laid in many kinds of artificial containers such as tubs, buckets, wheelbarrows, vases, boats, tin cans, and old tires. Trunks of oak trees, maples and old orchard trees may have tree-holes where rain water collects. These holes may be filled with mortar or drilled for drainage.

Special problems in rural areas

In rural areas special situations require attention. It has been computed that on a marshy pasture, mosquitoes can produce more than six million larvae per acre. This can often be prevented with a simple plow furrow cut through the pasture to provide a drain.

The fastest growing mosquitoes in hot weather require from 4 to 6 days in water to reach the adult stage. Field ditches that hold water for a considerable period of time may become a real source of mosquitoes.

Impounded water is not necessarily a breeding place for mosquitoes. A pond, for instance, will not sustain mosquitoes if its sides are properly graded and it is stocked with fish. In general, a steep-sided pond 3 feet or more in depth (to cover bottom-growing weeds) will present the least serious problem. The hiding places of larvae may be destroyed by removing weeds and brush from around the margin of the pond. This clearing, and the practice of suddenly lowering the water level, often helps to bring the mosquito larvae within reach of the fish.

Aside from ponds, other stagnant water requires special consideration.

Dairy drains and their overflow may be responsible for hordes of mosquitoes. These drains should be properly channeled and kept free from vegetation. Drainage may be directed into furrows to percolate into the soil. If this is not possible, a light spray application of kerosene or mineral oil to standing water at least once a week will destroy mosquito larvae.

Watering troughs and vegetable-washing vats make first-rate breeding places. The area around troughs may become roughened by hoofs of animals and contain hundreds of small water pockets. Drainage, paving, or the use of gravel eliminates breeding places. The tank itself should be cleaned occasionally during the summer. A few minnows in a deep watering trough effectively solve the problem without the use of toxic chemicals.

Prevention of Biting

Screens and aerosol sprays

Screening is the most effective way to keep mosquitoes out of the house. A full set of mosquito-proof screens gives excellent protection. However, it is quite possible to carry mosquitoes in on clothing, especially in a heavily infested neighborhood, late in the evening. These few invaders can be killed by an aerosol pyrethrum spray.

Mosquito netting and protective clothing

Mosquito netting is still one of the best means of outdoor protection. It is commonly used over baby carriages in the open and on camping trips. While hiking, picnicking, or engaged in other outdoor activities, even in hot weather, long-sleeved shirts and lightweight jackets may be invaluable. The color of clothing makes a considerable difference: mosquitoes are attracted to dark colors and avoid light ones. This is one reason for the popularity of white clothing in the tropics.

Repellents

Finally, people who hunt, fish, hike or picnic in areas heavily infested by mosquitoes can obtain a great deal of protection by the use of mosquito repellents. When mosquitoes are few, it is sufficient to treat the exposed skin. If mosquitoes are prevalent, the clothing may be treated as well. Several types of repellent are available at most drug and sporting goods stores. Effectiveness varies with the individual, but usually one treatment as directed will prevent biting for at least 2 hours. If mosquitoes are biting through the clothing, a light treatment of the cloth will suffice. Some repellents may damage synthetic fabrics, so should be used with caution. Cotton or woolen cloth is not affected. (These same repellents will also help to prevent biting by black flies which are occasionally a problem in Connecticut woodlands.)

Smoke and insecticidal fogs

Smoke has been recognized as a mosquito repellent from the time of the Indians and early settlers, who used a smudgy campfire and animal hair switches. From these early practices have been derived many modern

devices to emanate smoke and fog preparations which kill or repell mosquitoes. A recent innovation is the fogging attachment fitted on the exhaust stack of power lawnmowers. The exhaust gas is combined with an insecticide, producing a smoke which provides temporary relief from the biting pests in the yard.

DDT as a residual spray

The effectiveness of large-scale spraying in controlling adult mosquitoes has aroused a great deal of interest. In May of 1954, large areas of the State were sprayed for control of the gypsy moth — and in these areas mosquitoes were controlled for the rest of the summer. This led many groups of people to adopt this method of mosquito control. If spraying is done before the trees have heavy foliage, the deposit on the ground prevents breeding, but the area may be invaded by mosquitoes breeding outside the spray zone. Spraying later in the season coats the foliage of trees and shrubbery with enough DDT to kill the mosquitoes as they rest during the day. This combination works reasonably well, and two or three treatments a season in areas of 40 acres or more has been successful. Spraying by air is not very effective in dense woodlands where a heavy canopy of foliage prevents the spray from reaching the leaves of low-growing plants where the mosquitoes rest.

Application of Mosquito Control Principles

In the backyard, district, and community

In practice, mosquito control is like many other professional endeavors. It is largely a business of diagnosis and problem solving in which investigation plays a large part. Routine collection in probable breeding sites will soon indicate the sources of mosquitoes in a town. However, the investigation of complaints is important in mosquito control. The time of day when mosquitoes are most bothersome, and where they are biting (for example, out in the yard or in the bedroom) give clues to the identity of the species involved, its probable origin and, hence, the most likely places to inspect for larval breeding. Since much of the pest mosquito problem originates in the area around the home, property owners can locate and eliminate the breeding place with a little investigation of their own backyard. If the mosquitoes are coming from the property of a neighbor, cooperation is necessary for effective control. If more than domestic pest species are involved, however, the organization of a mosquito control district is often indicated.

Control of pest species vs. control of disease vectors

The State Department of Health has published a circular, "Mosquito Control in Local Communities," which recommends specific steps to be taken in control district organization (15). Therefore, the subject will not be discussed here except to point out that in planning a rational program, a basic decision is necessary. The people in the town must decide whether they want to control all mosquitoes including the major pest species, or to control only those species which are dangerous as disease transmitters. In the latter case, much of the mosquito season and many of the pest species may be ignored. The eradication of disease

transmitters may be accomplished very rapidly in this era of mobile power equipment, should an emergency occur. However, the amount of money needed for this purpose can buy an entire season of mosquito abatement that includes control of major pest species.

Regardless of the policy that is chosen, *large-scale use of insecticides should be for temporary or emergency mosquito control only,* pending application of primary sanitary measures.

Mosquito Control and Wildlife

The "balance of nature"

Mosquito control procedures, particularly the use of DDT, have been criticized as undue interference with the "balance of nature," resulting in long-term harm to birds and wildlife. Any method of mosquito control upsets the balance of nature. Ditching and draining does not depend on chemicals, but eliminates aquatic insects other than mosquitoes, and possibly changes the distribution of marsh birds. It is true that careless use of insecticides around a marsh may kill wildlife, but so can careless ditching and filling of swamps.

Approved use of insecticides can be safe

This problem has been debated since the earliest days of mosquito control. Perhaps all that can be said further is that the people who are being bitten have to decide whether they prefer to let nature alone or to control the mosquitoes. When, however, the use of DDT is necessary to control mosquitoes, by following the recommendations for the *approved* use of insecticides the harmful, sometimes over-publicized, effects on wildlife can be avoided, and insecticides applied safely. The U. S. Public Health Service has demonstrated that DDT dusts can be routinely applied at one-tenth-pound per acre with little significant harm to aquatic organisms. They have shown that DDT sprays or thermal aerosols from airplanes can be applied at that dosage for up to 3 years without harm to fish.

Regulation of DDT application from aircraft

Few people realize that during the past 5 years more than 20,000 acres in Connecticut have been sprayed with DDT from aircraft for mosquito control, without disastrous effects on birds, fish, or wildlife. This fine record for safe use of insecticides has been the result of rational, conservative, cooperative planning and supervision by the officials in the State who are responsible for protection of its people, and its crops and wildlife. Before any insecticide may be applied from airplanes, a permit must be obtained from the Connecticut Department of Aeronautics. The conditions of the permit and regulation of materials, dosages, and areas to be sprayed are established by a joint administrative committee composed of one member from each of the following state agencies: Department of Aeronautics, The Connecticut Agricultural Experiment Station, Board of Fisheries and Game, and the State Department of Health. The regulations established by this committee are designed so that permits may be issued for aerial application with the least possible delay and at the

same time safeguard public health and safety, protect fish and wildlife, and safeguard the right of the individual to control what is placed on his land.

Bibliography

1. *Britton, W. E., and Viereck, H. L.* 1904. Report on mosquito investigations in Connecticut. Report of The Conn. Agri. Exp. Stat., 253-308 + 7 pl.
2. *Britton, W. E.* 1912. The Mosquito Plague of the Coast Region and How to Control It. The Conn. Agri. Exp. Stat. Bull. 173. 24 pp.
3. *Bates, Marston.* 1949. The Natural History of Mosquitoes. Macmillan, New York. xv + 379 pp.
4. *Wallis, R. C.* 1954a. Effect of population density and of NaCl concentrations in test series in laboratory experiments with ovipositing *Aedes aegypti.* Mosq. News, 14(4):1-5.
5. *Wallis, R. C.* 1954b. A study of the oviposition activity of mosquitoes. Amer. Jour. Hyg., 60(2):135-168.
6. *Walllis, R. C.* 1955. A study of the oviposition activity of three species of *Anopheles* in the laboratory. Amer. Jour. Trop. Med. and Hyg., 4(5): 557-563.
7. *Barr, A. Ralph.* 1958. The Mosquitoes of Minnesota (Diptera: Culicidae: Culicinae). Tech. Bull. 228: Univ. Minn. Agr. Exp. Sta., St. Paul. pp. 154.
8. *Horsfall, W. R.* 1955. Mosquitoes. Their Bionomics and Relation to Disease. Ronald Press, New York. viii + 723 pp.
9. *Lang, C. A., and Wallis, R. C.* 1956. An artificial feeding procedure for *Aedes aegypti* using sucrose as a stimulant. Amer. Jour. Trop.Med. and Hyg., 6(5):915-920.
10. *Headlee, T. J.* 1945. The Mosquitoes of New Jersey and Their Control. Rutgers Univ. Pr. x + 326 pp.
11. *Carpenter, S. J., and La Casse, W. J.* 1955. Mosquitoes of North America. Univ. of Calif. Pr., Berkeley and Los Angeles. pp. vii + 353 +127 pl.
12. *Wallis, R. C., Taylor, R. M., McCollum, R. W., and Riordan, J. T.* 1958. Study of hibernating mosquitoes in eastern equine encephalomyelitis epidemic areas in Connecticut. Mosq. News. 18(1):1-4.
13. *Wallis, R. C.* 1959. Diapause and fat body formation by *Culex restuans.* Proc. Ent. Soc. Wash., 61(5):219-222.
14. *Wallis, R. C., Taylor, R. M., and Henderson, J. R.* 1960. Isolation of eastern equine encephalomyelitis virus from *Aedes vexans* in Connecticut. Proc. Soc. Exp. Biol. and Med. (In press).
15. *Elston, J.* 1957. Mosquito control in local communities. Conn. State Dept. of Health Circ., 6-59. Reprinted from Connecticut Health Bull. 71(2), (Feb., 1957).

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